UW Polar Science Center Sea Ice Model(s)

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UW Polar Science Center Ice Model Family

PIOMAS:

- **P**anarctic **I**ce **O**cean **M**odeling and **A**ssimilation **S**ystem
- Standard work horse: Ice volume time series, seasonal-forecast, thickness for initialized experiments

MIZMAS:

- **M**arginal **I**ce Zone **M**odeling and **A**ssimilation **S**ystem
- Higher resolution grid. Floe Size Distribution

BIOMAS:

- **M**arginal **I**ce Zone **M**odeling and **A**ssimilation **S**ystem
- Ecology, Nutrients, Primary Productivity

GIOMAS:

- **M**arginal **I**ce Zone **M**odeling and **A**ssimilation **S**ystem
- Global grid, used for open boundary conditions, Antarctic

All developed by Jinlun Zhang (UW). Common ice physics, ocean model, differences in grid layout and parameterization

Key Features

- **Ocean Model: POP (Parallel Ocean Program)**
- **Generalized curvilinear grid. Layout and resolution depends on variant**
- **Parallel multi-category (12) thickness & enthalpy distribution (TED) sea ice model; multi-category snow depth distribution (*Zhang/Rothrock* 2003).**
- **Sea ice dynamics model with Teardrop-Plastic Rheology (Zhang and Rothrock, 2003)**
- **Thermodynamics: 3-layer (Winton 2000)**
- **Numerical Solver: Line Successive Relaxation (LSR)**
- **Nested (one-way) to a global ice-ocean model (GIOMAS) for open boundary conditions**
- **Tidal forcing (up to 8 components)**
- **NEW: Prognostic Floe Size Distribution (Zhang et al. 2015)**
- **In development: Melt Pond Parameterization**
- **Assimilation capabilities: Satellite sea ice concentration and SST, Optimal interpolation, nudging (Lindsay and Zhang, 2006)**

# Forcing and Initialization

- Atmospheric Forcing
  - Downwelling SW, LW, Tair (2m), Q (2m), U (10m)
  - Source: NCEP/NCAR Reanalysis atmospheric forcing (default). But also ERA-40, ECMWF Operational, ERA Interim, MERRA (1), ERA20C, NOAA R20Cv2c, CFSR, CFSv2 hindcast, CFS (forecast)
  - 6-hourly-to daily timesteps

- Initialization
  - Depends on experiment. Typically spin up using 30 years of one year, thickness set to 2m where freezing, or previous model state, model ice thickness bias corrected to observations (IceBridge, Lindsay at el. 2012), open boundary conditions from global model (GIOMAS)

- Assimilation data
  - Ice Concentration: NSIDC Near Real Time (default), also HadISST1 and 2
  - SST: Reynolds

- Time Coverage
  - Hindcasts: 1979-present, currently working on (1900-2010), daily
  - Forecasts: Seasonal, 9-day

Calibration/Tuning

- **Mean ice thickness calibrated with in situ ice draft/thickness data over 1975–2009** *(UW Unified Ice Thickness data base, Lindsay, 2010)*

- **Ice motion calibrated with IABP buoy drift data over 1979–2010**

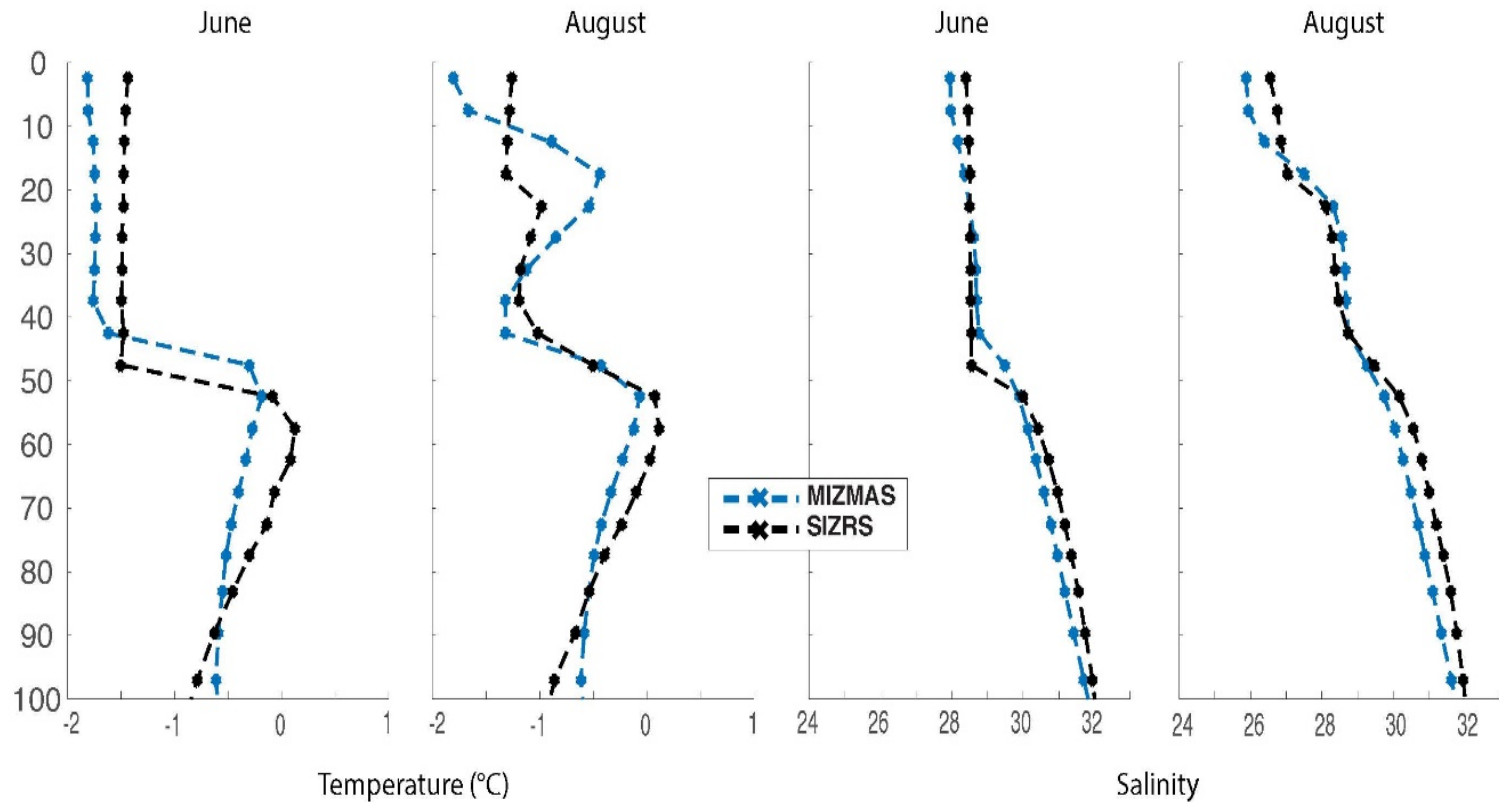- **Tuning parameters: albedo, surface air drag/roughness**

Ice Thickness Validation

Time series of observations and Model at location of observation
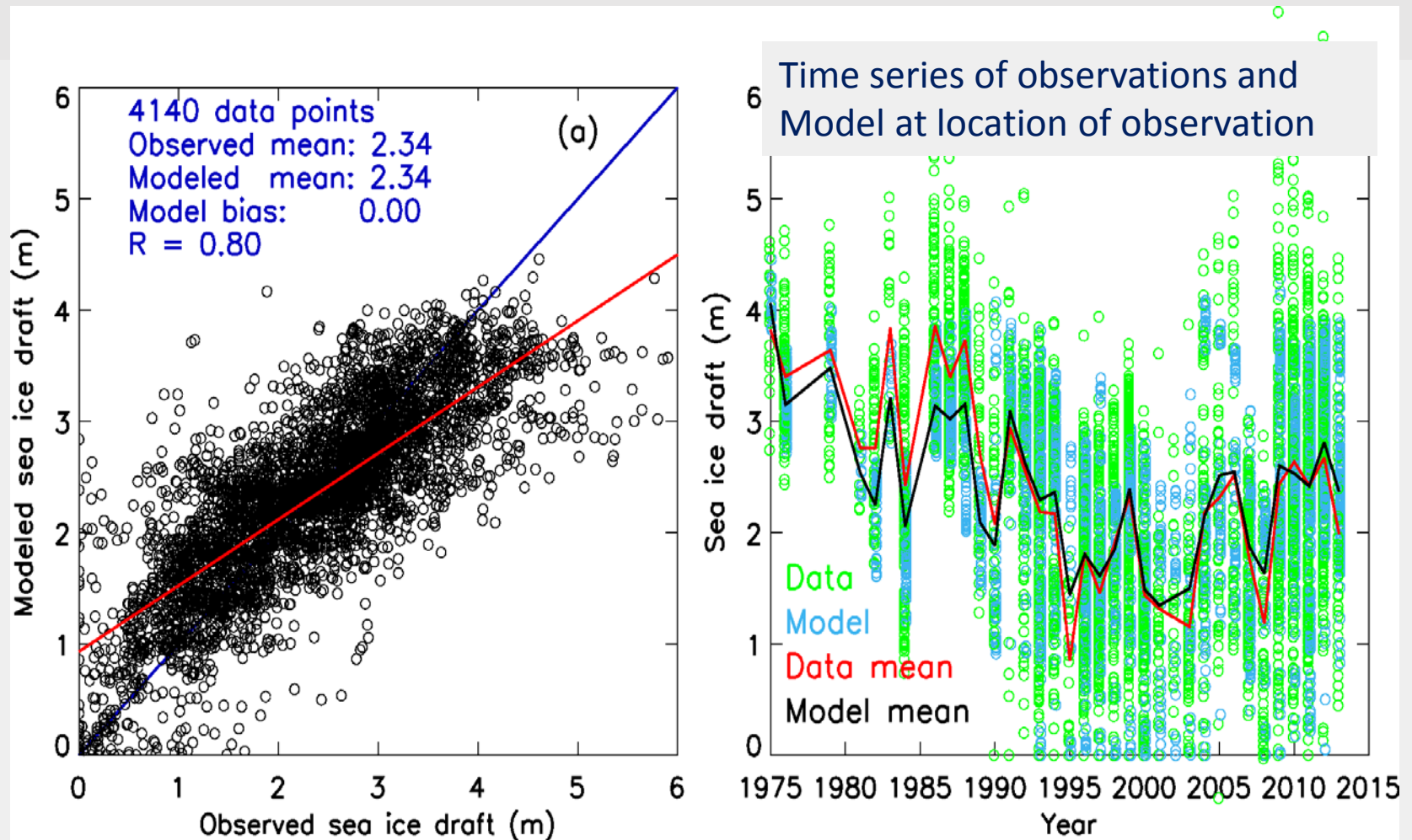
In situ ice thickness observations from the PSC/UW Unified Sea Ice Thickness Climate Data Record (*Lindsay, 2010*)

Ocean Temperature and Salinity Validation
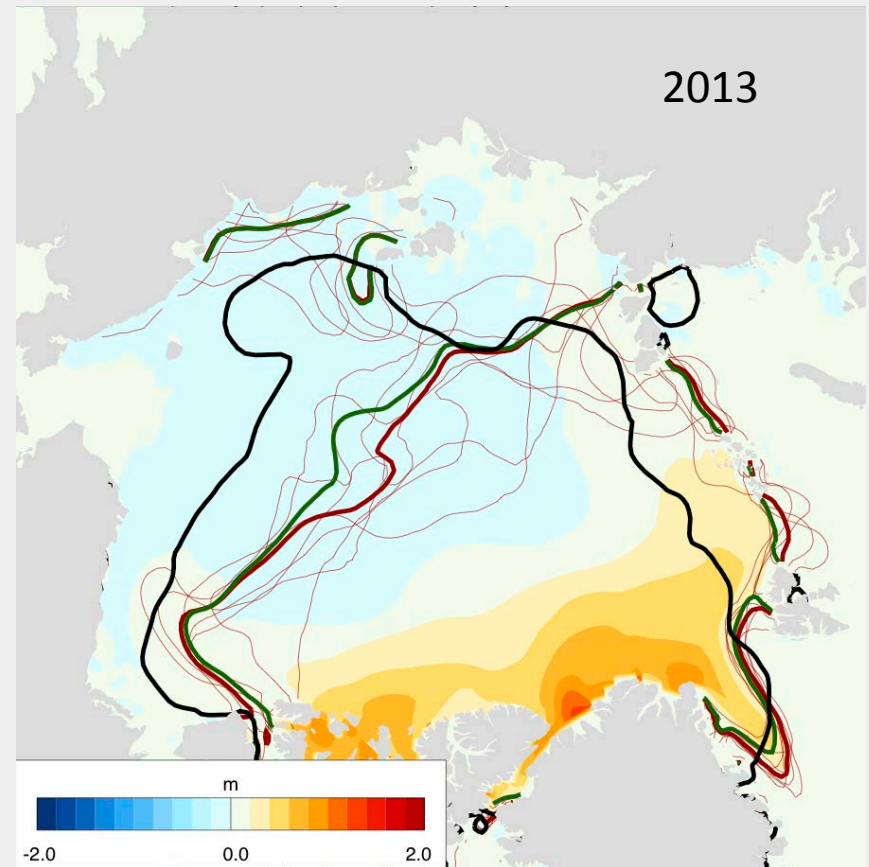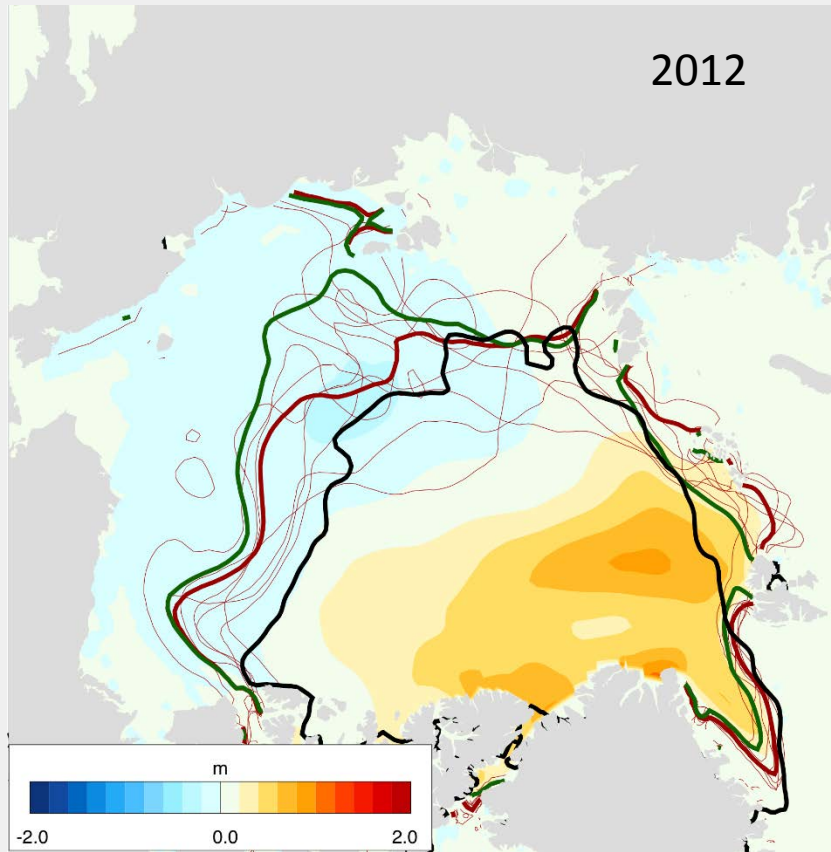# Model and SIZRS Observations

2013, 76°N 150°W

SIZRS: Seasonal Ice Zone Reconnaissance Surveys

Seasonal Forecast Verification, IceBridge Ice Thickness Initialization Impact
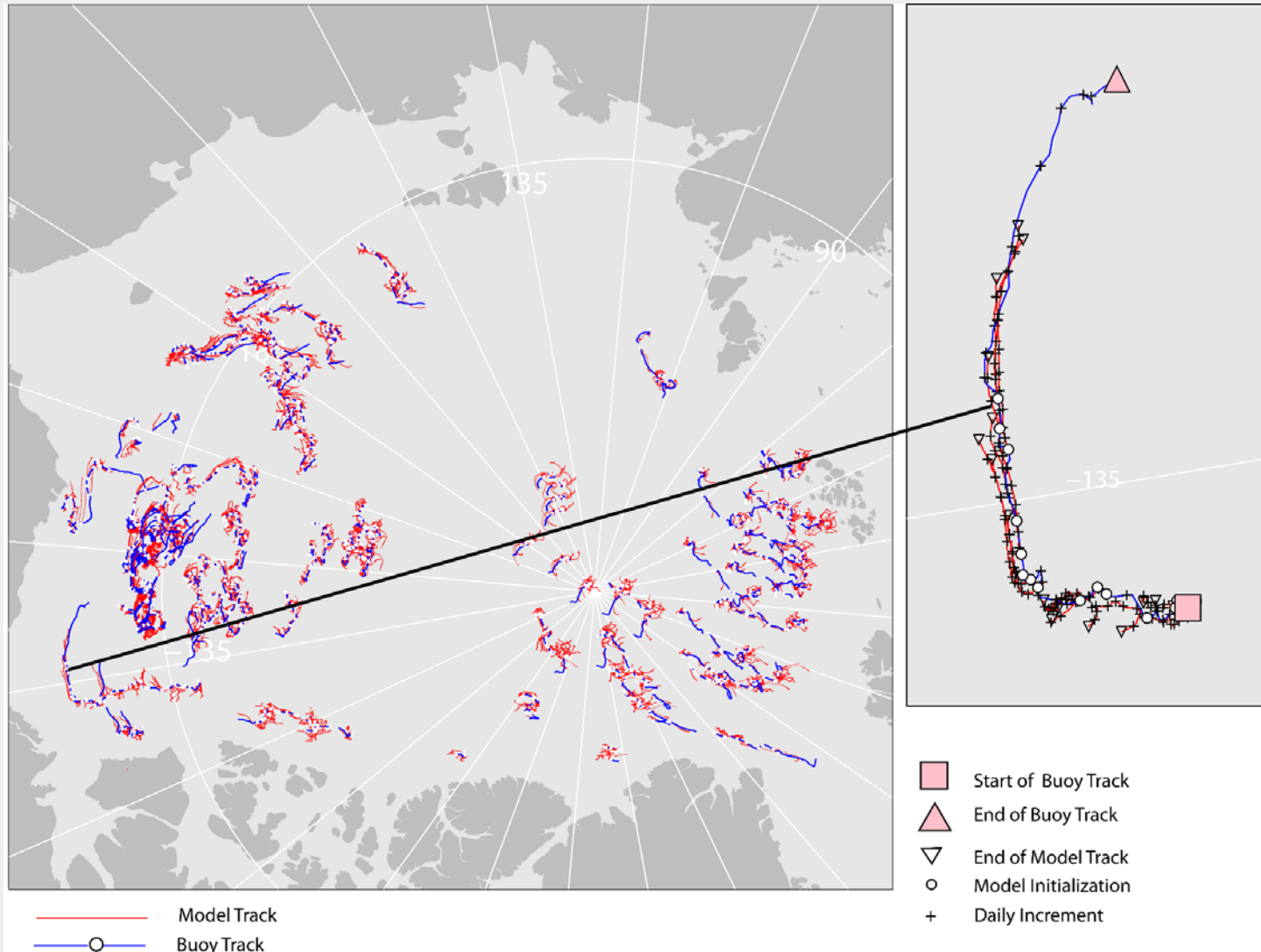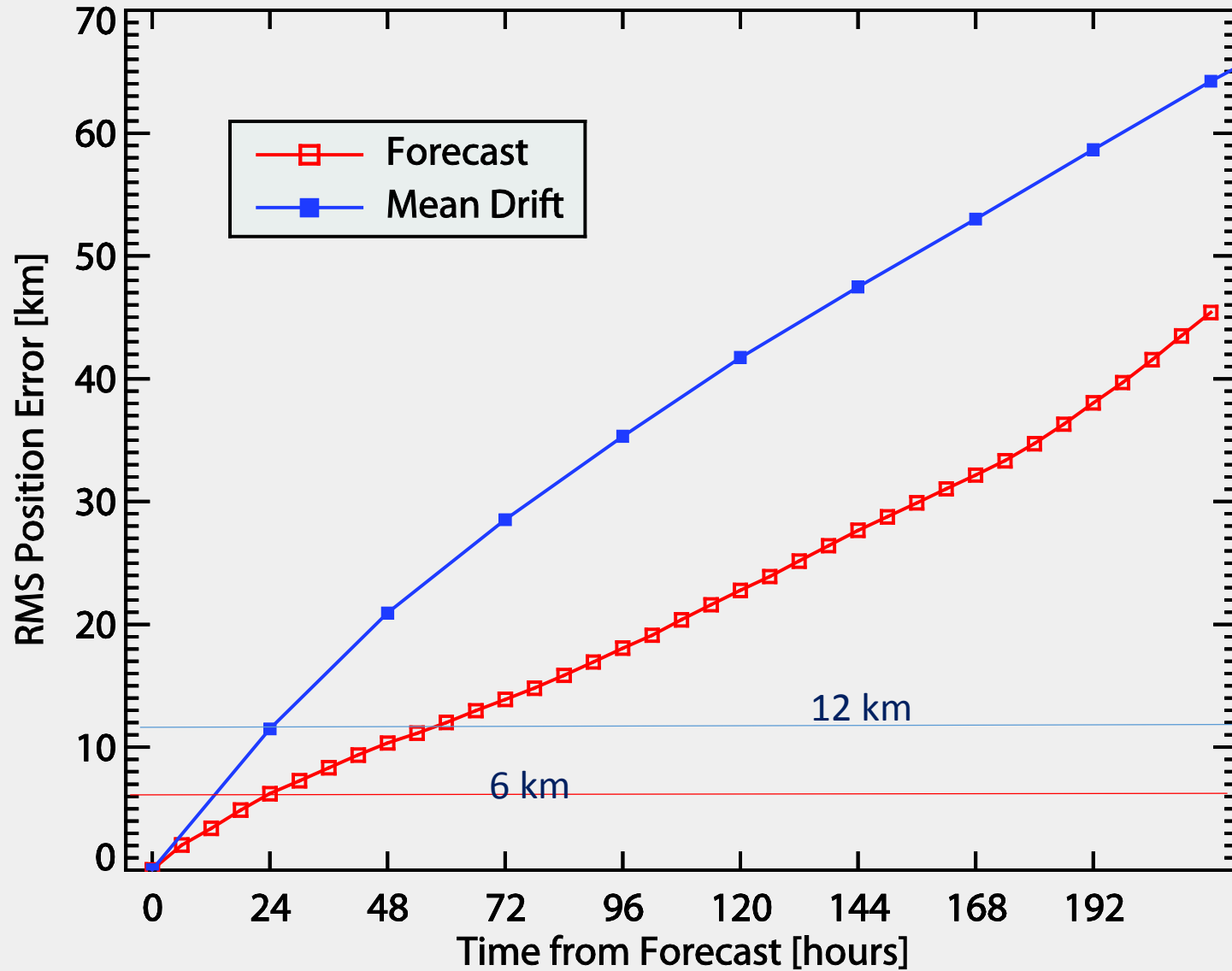

2012

2013

black: Observed September Ice Edge
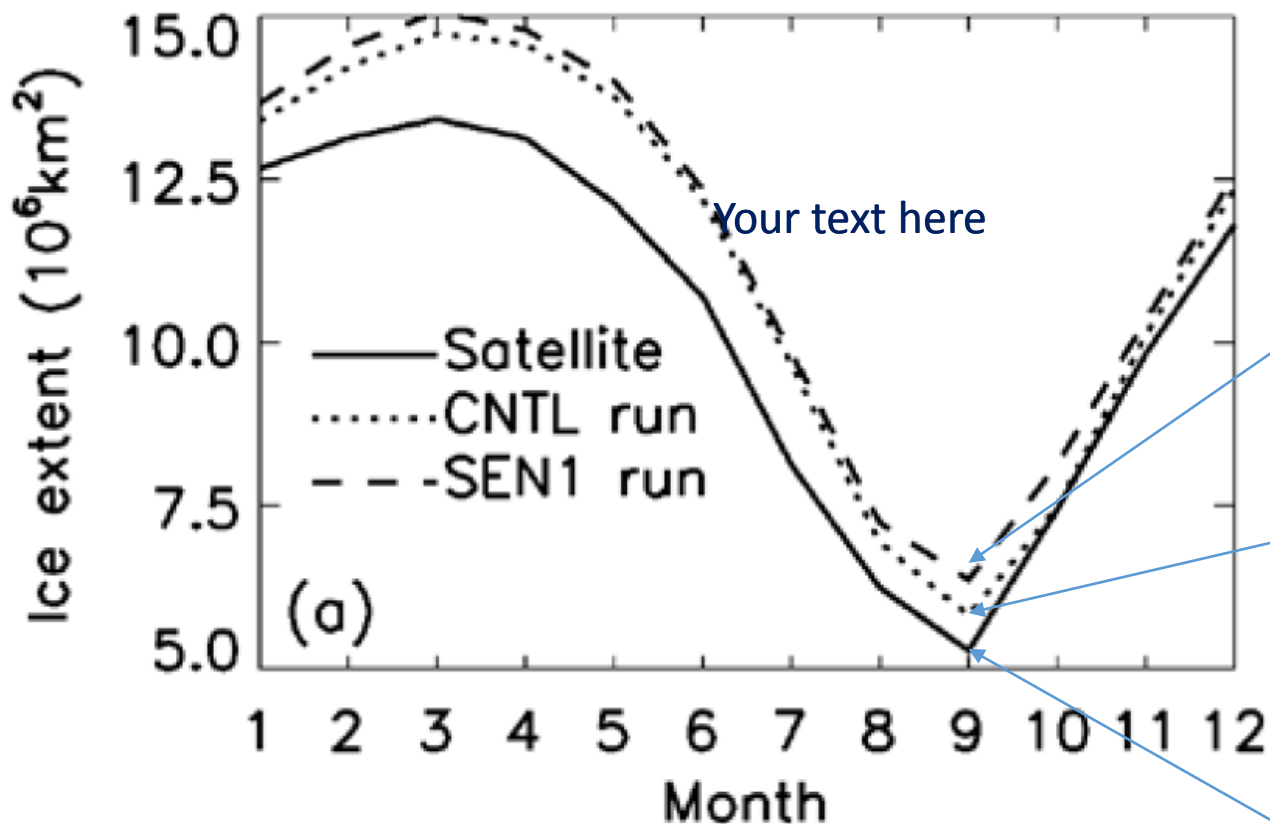Green: no IceBridge initialization
Red: IceBridge Initialization

Short term (9-day) forecast verification using NOAA CFS forcings

Start of Buoy Track
End of Buoy Track
End of Model Track
Model Initialization
Daily Increment

Model Track
Buoy Track

See Schweiger and Zhang, 2015

Ice Drift Position Errors

Impact of Floe Size Distribution on Ice Extent Simulation

- PIOMAS Ice thickness/volume widely used for comparison, initialization of model (GCM) experiments.
- Regular Contributor to SEARCH Sea ice outlook, SIPN
  - Physical ensemble forecast, initialized forecast, statistical forecast based on model state
- Documentation
  - Largely in scientific publications. No user level documentation
- Code Availability
  - Variants (2 category thickness) have been integrated into MITGcm, NASA GISS-ModelE and code is available as part of those packages
  - Some work (scientist/programmer) would be needed to integrate current version into another system and create user level documentation